bYOB [Build Your Own Bag]:

A computationally-enhanced modular textile system

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ABSTRACT

We present bYOB (Build Your Own Bag), a flexible, computationally enhanced modular textile system from which to construct smart fabric objects. bYOB was motivated by a desire to transform everyday surfaces into ambient displays for information and to make building with fabric as easy as playing with Lego blocks. In the realm of personal architecture, bYOB is an interactive material that encourages users to explore and experiment by creating new objects to seamlessly integrate into their lives. The physical configuration of the object mediates its computational behavior. Therefore, an object built out of the system of modular elements understands its geometry and responds appropriately without any end-user programming. Our current prototype is a bag built out of the system that understands it is a bag when the handle is attached to the mesh of modules, responds by illuminating its fabric and inner contents when the sun goes down (Fig 1), communicates the presence of objects placed in the bag, and interacts with the user via speech. We describe how bYOB contributes to and differs from existing work in modular based systems and fabric interfaces. We discuss our development process in respect to physical, electronic, and conceptual design. We also describe salient features and future applications enabled by this new construction kit.

Keywords

Ambient Interface, Tangible Interface, Customization, Enhanced Situational Awareness, Fabric Building Blocks, Modular Systems, Network Detection.

1. INTRODUCTION

bYOB's significance is that anyone can make an object at any time and anywhere whether they are a designer with a new vision, an office worker in need of additional light, or a student who needs useful information while in transit but does not want to carry several additional electronic devices. Therefore, the modules allow users to express themselves and create interactions with their environment. Rather than needing to carry several electronic devices to access these applications, bYOB exploits everyday surfaces as a natural medium by which to communicate information.

Figure 1: Current prototype demonstrating light sensing capability.

On a conceptual level, bYOB seeks to challenge the conventional ways in which technology, its producers, and the role of the intended 'beneficiary' or user, are viewed; the common notion that the technology dictates how we use it obscures its potential as an interactive outlet. By using a modular textile system, the user is not divorced from the creative process. The human computer interaction that is afforded is one that is aware of the changing needs and capabilities of people and environments, yet is dually cognizant of a wider creative evolution.

When designing applications for bYOB, we were inspired by the lifestyles of today's students and professionals. Our target audience can be characterized in part by their mobility — constantly moving between home, work, school and personal commitments. As a responsive tangible interface, bYOB can be customized to fit their unique needs. For example, a set of bYOB modules may be physically configured into a window shade or lighting fixture in the office and later be reconfigured into a bag or scarf to aid the user in transit.

1.1 Current Applications

Environmental Awareness. bYOB modules are equipped with sensors to respond to changes in, for example, light level and temperature. Our current prototype illuminates the contents of the bag when ambient illumination drops below a desirable level.

Object Detection. Using radio frequency identification, bYOB modules can detect whether or not important objects (e.g. cell phones, wallets) are nearby and alert the user, through the fabric's ambient light display or using speech, if the items are missing. For example, a bYOB-constructed bag will light up to inform the user if he or she tries to leave home without keys.

Topology Mapping. The modules are dynamically aware of their configuration and understand geometries other than those of bags. A wall hanging may be configured and act as a light source or a curtain may be constructed to respond appropriately to environmental changes (Fig 2).

1.2 Applications Under Development

Wireless Capability. Using the Bluetooth protocol, bYOB modules will be able to download information from the Internet (e.g. weather forecasts) to the modules. Additionally, the user will have the ability to 'log in' to one or more remote bYOB bags from a computer and search for the location of items.

Network Detection. Mobile lifestyles often lead to increased use of mobile phones, PDAs (personal digital assistants) and laptop computers. However, the wireless networks used with these items are not immediately visible. Through the ambient display, bYOB modules can make information regarding the existence and strength of networks readily available.

Seamless Integration Into Our Lives. We envision that when you hang your bag up for the day, it will automatically recharge its battery and synchronize itself with other objects in the bYOB network.

Figure 2: bYOB can detect environmental changes actuated through ambient light display.

2. RELATED WORK

There are several examples of modular based computational interfaces developed for various applications that have informed our research. One such system, Triangles [2], used for non-linear storytelling but available for other applications, most closely parallels bYOB in its ability to allow users to handle and manipulate digital information with construction pieces. While both Triangles and bYOB serve as displays for information, the modules of bYOB are used to transform familiar physical surfaces, and the technology is specifically designed for use as a flexible fabric interface.

Wifisense, a wearable scanner for wireless networks, is a self-contained handbag that conveys WiFi availability through a pattern of light and sound. [5] Unlike Wifisense, bYOB's design approach is of embedding systemic behavior inside modules of fabric to provide a novel approach for building objects. Additionally, bYOB creations can serve multiple purposes over a wide range of applications, not limited to the interface of a bag.

E-broidery or conductive fabric was examined as a possible prior work to build on. E-broidery is attractive in its ability to replace standard circuitry with flexible, washable substrates. After examination into the current state of conductive threads however, we discovered that the integrity of the threads is in question as they may be apt to break when subjected to stress. Additionally, we learned that they must endure a lengthy process of welding and sewing. An alternate design used in bYOB achieves similar freedom of movement without laborious manufacturing processes, an important requirement since many bYOB modules must be fabricated. Nonetheless, E-broidery remains a subject of study and further research is being done to investigate whether or not it is possible to replace some of the wiring with conductive fabric traces [4].

bYOB's contribution marries notions of ambient communication with tangible media to allow for the creation of personal architecture. It encourages rapid exploration in the manipulation of fabric and is a universal approach because it assumes no formal design training and little computational experience. The 'digital language' expressed by the object is made unambiguous because the user is in control of the physical form and light pattern display.

3. PHYSICAL DESIGN

The current bYOB prototype consists of squares and equilateral triangles approximately 4"x4" and no more than 1/8" thick. The simple geometries of squares and triangles were chosen because they are easily recognizable and can be effortlessly manipulated into two and three-dimensional shapes. Additionally, the dimensions were chosen to fit comfortably when grasped by the human hand.

The task of constructing a connection to fit securely and easily with neighboring modules as well as transmit data and power posed a significant challenge in the development process. Several approaches for the modules' physical connectors were examined including snap-hinges, screws, zippers, and magnetic/metal snaps. At first, we choose commercial metal snap connectors acquired from a fabric store because of their unambiguous design and their performance as conductors. The snaps were disappointing because their aggregate weight compromised the feel of the fabric. Our current prototype employs conductive hook-and-loop material that is lightweight and has impressively low resistance, allowing data to be exchanged between modules. The simplicity of snapping pieces together with hook-and-loop allows the user to, at any time, add or subtract modules from an object to fulfill a situational change or geometric design. Additional time was spent ensuring that the male/female snaps on each module were part of an intuitive design where the user would not have to understand the technical complexities of lining up power, ground, and data pins (Fig 3).

Lightweight foam padding inside each module provides cushioning against the electronics. We are currently experimenting with different types of synthetic and natural fabrics for the outside of bYOB module shells. The material must be weather proof and have the ability to dissipate light from the LEDs. However, the fabric we are looking at is merely a suggestion of what the object might look like. Using the innovative Dual Lock material by 3M stitched to the outside of the modules as well as to the fabric, users have the ability to constantly change the fabric coverings of their objects.

4. TECHNICAL DESIGN

The system is comprised of three different types of modules: passives, actives, and parents. Active and parent modules contain an array of sensors, light actuating elements and a microprocessor. Passive modules, while physically identical on the exterior to the active modules, have the sole purpose of contributing structural support and physical form and therefore contain no light actuation or computational capabilities.

The parent module differs from the actives in that it controls the algorithm to equip the rest of the modules with appropriate applications. The shape of the parent module is dependent on the object created. For example, if the user builds a bag, the handle is designated the parent and alerts its children that they are part of a bag and should respond correspondingly (with object and network detection applications).

To ensure that bYOB is not cost-prohibitive as an end-user technology, emphasis was placed on using inexpensive electronics and on power conservation. The current design of each active module houses a 1-inch square printed circuit board covered in epoxy resin to level height and imbued with modest processing to locally manage communication, actuator response, and its own unique identity. The PIC16F876 microcontroller was chosen because of its low current consumption and because it works well with the I2C bus, the network by which a mesh of modules communicate. I2C was chosen because of its minimal cost and its plug and play ability. [3] For actuation, each active module uses RGB LEDs (light emitting diodes) to illuminate the fabric that covers the board. With several illuminated active modules, an ambient light pattern emerges.

For greatest efficiency and to conserve space, it was decided that data and power would be distributed through the network of modules. The conductive hook-and-loop material that acts as a mechanical connection between pieces also transmits power and data through the object. Four connections on each side provide power, ground, and the data and clock connections required by the I2C bus. As discovered in the research of Computational Building Blocks, a building kit for geometric modeling, using self-powered modules would greatly increase the cost and maintenance of each piece within the construction kit. [1] Instead, power is currently drawn from a centralized rechargeable battery piece. During development of the modules, emphasis was made on minimizing power consumption: the microprocessor in each module draws less than 1 mA (milli-ampere), and high-brightness low-current LEDs were chosen to maximize light output while keeping current draw low.

The current bYOB module implementation accommodates transducers and sensors for light and temperature and actuators for speech allowing interaction with the user in a natural way. Modules can be outfitted with additional sensors to respond to pressure and orientation.

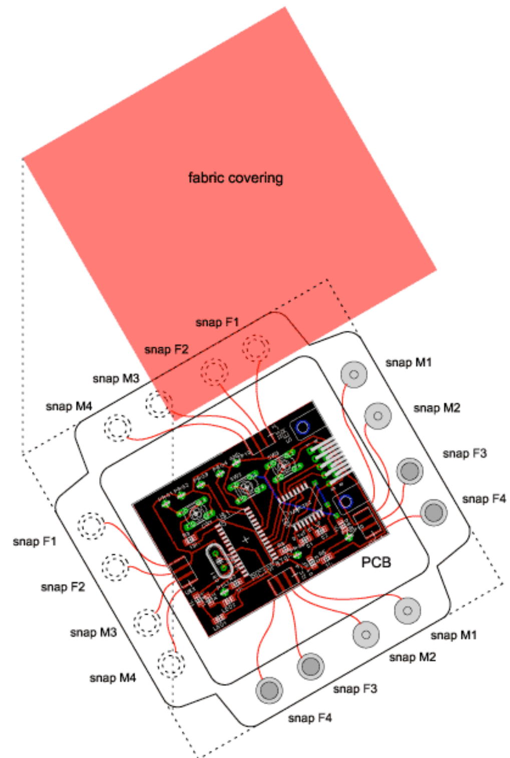

Figure 3: Module with PCB and connector layout

Given the negligible size of the circuit board, the use of fabric-based connectors and flexible cable, and the cushioning provided by the foam-fabric combination, modules effectively mask their technical belly, preventing them from coming into contact with the user's body. In subsequent designs we expect to see a decrease in the size and weight of each module's inner contents thus increasing usability.

Additionally, by using waterproof fabric and electronics covered in epoxy we ensure that the modules are durable and washable.

Figure 5: BYOB encourages user design

5. EVALUATION

An important part of our development process is feedback from potential users of bYOB. We conducted a survey with local college students to find out what information and objects constructed out of bYOB would be most useful and what the strengths and weaknesses of the project were.

Our respondents showed enthusiasm for this application, particularly its ability to light up at night and alert users of missing items. There was concern about the durability of the system. If they were to invest in bYOB as a product, they would want to ensure that it would last a long time. Taking this feedback into account, we are developing physical connections that have negligible wear over time and looking into materials that are weather-resistant.

Furthermore, while almost all of our respondents considered themselves creative and said they would enjoy building objects with bYOB, they voiced concern about the time commitment bYOB might require. In response, we are refining the design to ensure that physical connections are minimal and work effortlessly. As the project progresses, we will continue to gather user feedback and observational data from a wider demographic.

6. FUTURE WORK AND CONCLUSIONS

Through further development, we hope to better understand bYOB's challenges and limitations. It is likely that we will confront the challenge of making the modules scalable to accommodate shapes and sizes different from triangles and squares of uniform size. Because it is a textile that can be used for interiors, bags and accessories, it is crucial that the system is aesthetically appealing to users, allows freedom in design, and durable enough to withstand frequent use.

The user-interface is constantly being refined so that bYOB couples seamlessly with the kinds of interaction we are already accustomed to. As part of a distributed sensor network, we envision several bYOB objects that synchronize with each other and facilitate visual data exchange. A bYOB curtain would respond to changes in weather like the onset of rain and dually inform a bYOB bag that it should contain an umbrella.

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